Kroeber Anthropological Society Papers, Nos. 71-72, 1990

Morphology and Metrics of the Upper Third Molars of *Australopithecus afarensis*

Pelaji S. Kyauka

This paper presents comparative data for the upper third molars attributed to Australopithecus afarensis *from the sites of Laetoli and Hadar. The analysis is based on morphological and metric characters. The metric data show that specimens A.L. 200-1a and A.L. 333x-1 are more similar to each other than they are to the other known upper third molars of* A. afarensis. *Morphologically, the upper third molars of* A. afarensis *from Laetoli and Hadar are similar in many of the features compared. This observation suggests that the Laetoli and Hadar specimens attributed to* A. afarensis *are not heterospecific.*

INTRODUCTION

Morphological and metric studies of the dental characteristics of *Australopithecus afarensis* can provide vital data for clarifying its integrity and relationship with other hominid species. Although studies of this nature are important, few attempts have been made (see White 1985; Leonard and Hegman 1987; Cole and Smith 1987).

The naming of *Australopithecus afarensis* as a new taxon by Johanson *et al.* (1978) included the pooling of specimens from Laetoli and Hadar. A number of researchers, including Tobias (1980), questioned this rationale. Tuttle (1981a, 1981b, 1985, 1987), for instance, doubted the possibility that a creature resembling *A. afarensis* from Hadar made the footprints found at Laetoli. Furthermore, some questions have been raised on whether the specimens attributed to *A. afarensis* from Hadar represent one species or more than one species (see, for example, Coppens 1977, 1980, 1981, 1983; Ferguson 1983, 1984; Herbert 1983; Leakey 1981a, 1981b; Olson 1985; Senut and Tardieu 1985; Tardieu 1986; Zihlman 1985). However, others (e.g., Blumenberg and Lloyd 1983; Leonard and Hegman 1987; White 1985; White and Suwa 1987) have shown that the single species argument for the Hadar hominid fossils and the pooling of the Laetoli and Hadar specimens are justified. For more than ten years, then, the integrity of *A. afarensis* has been a subject of continuous and vigorous debate. The debate is not yet over (Ferguson 1989). The present paper uses the general morphological and metric features of the upper third molars attributed to *A. afarensis* known from Hadar and Laetoli as a further attempt to resolve this controversy.

MATERIALS AND METHODS

A comparison of morphological and metric characters of the upper third molars of *Australopithecus afarensis* specimens recovered from Laetoli, Tanzania and Hadar, Ethiopia is given. Morphological descriptions are based on terminologies and techniques used by Grine (1984), White (1977, 1980), Biggerstaff (1969) and Johanson *et al.* (1982).

Metric and morphological comparisons were made using published data and observations of the casts of fossils A.L. 199-1, A.L. 200-1a, A.L. 333x-1, A.L. 161-40 and A.L. 388-1 from Ethiopia, and L.H. 5, L.H. 12, L.H. 8(b) and Garusi II from Laetoli, Tanzania.

MORPHOLOGICAL ANALYSIS

Occlusal View

The occlusal surface outline of Garusi II, like that of A.L. 200-1a (right and left), A.L. 333x-1, L.H. 5, A.L. 199-1 and A.L. 161-40, is a round angled rhomboid, unlike that of L.H. 8(b), which is more circular. The outline of the occlusal view of the basal area of A.L. 199-1 and Garusi II is rhomboidal, while that of A.L. 200-1a, A.L. 333x-1, A.L. 161-40, L.H. 8(b) and L.H. 5 is heart-shaped or triangular, with mesially placed apices, distally placed hypotenuses and lingually placed bases.

The distocclusal groove of L.H. 5 runs almost parallel to the distal marginal ridge. The distocclusal grooves of A.L. 200-1a (right and left), A.L. 333x-1 and A.L. 161-40 run distally on the occlusal surface until they intercept the median longitudinal groove, distobuccal foveal groove and the distolingual foveal groove at the posterior fovea.

The A.L. 200-1a (left) and A.L. 161-40 distobuccal cusps are incised into two cusps, and the area between the cusps of A.L. 161-40 is pitted. The right A.L. 200-1a metacone is notched into five cusps while those of A.L. 199-1 and A.L. 388-1 are notched into three and four cusps, respectively, by their distobuccal foveal grooves.

The A.L. 388-1 metacone has three cusps which are not formed by the distobuccal foveal groove.

The distal trigon crest of A.L. 333x-1, like that of A.L. 161-40, A.L. 200-1a and A.L. 199-1, is well-developed and notched by the median longitudinal groove. A well-developed plagioconule is formed on the lingual side of the distal trigon crests of A.L. 200-1a and A.L. 199-1. Due to wear, the presence of a plagioconule on L.H. 5, Garusi II and L.H. 8(b) cannot be determined.

The anterior fovea of A.L. 161-40 is a straight fissure placed on the mesial side of the paracone. It is bordered by the mesial marginal ridge and the epicrista on its mesial and distal sides, respectively. A.L. 200-1a has an S-shaped broad and deep anterior fovea which runs along the marginal ridge with the epicrista on its distal side. A.L. 199-1 has a pit-like anterior fovea placed at the midline of the distal side of the mesial marginal ridge with no epicrista on its distal side. The anterior fovea is not well-developed on A.L. 333x-1.

The median longitudinal groove of A.L. 161-40, like that of A.L. 200-1a (right and left) and A.L. 199-1, appears to begin at the distal side of the epicrista. It crosses the trigon crest and ends at the posterior fovea. The median longitudinal groove of A.L. 333x-1 seems to start directly at the edge of the mesial marginal ridge.

Secondary crenulations are minimal on L.H. 5, A.L. 199-1 and A.L. 161-40, but prominent on A.L. 200-1a, A.L. 333x-1 and L.H. 12. Because of wear, it is difficult to assess the extent of secondary fissuration on Garusi II and L.H. 8(b).

Lingual View

The lingual surfaces of A.L. 200-1a (left) and L.H. 5 have a lingual groove which shows a slight distal curvature. A.L. 200-1a (right), A.L. 161-40 and A.L. 333x-1 have lingual grooves which are straight and inclined distocclusally. Unlike L.H. 5, the lingual grooves of A.L. 200-1a, A.L. 161-40 and A.L. 333x-1 form wide V-shaped grooves as they cross the lingual marginal ridge. The lingual surface of Garusi II shows a slight concavity, especially close to the lingual marginal ridge. The A.L. 200-1a, A.L. 333x-1, A.L. 199-1 and A.L. 161-40 lingual surfaces are slightly bilobed by the lingual groove, while L.H. 5 and L.H. 8(b) are relatively convex and flat, respectively. The cervical lines of A.L. 199-1, Garusi II and L.H. 5 bulge upwards on the lingual surfaces while they are relatively straight on L.H. 8(b), A.L. 333x-1, A.L. 200-1a and A.L. 161-40. The lingual surface of the A.L. 333x-1 protocone is heavily crenulated.

Buccal View

The paracones of Garusi II, L.H. 12, L.H. 8(b), A.L. 333x-1, A.L. 200-1a, A.L. 199-1, A.L. 161-40 and probably L.H. 5 protrude buccally more than the metacone. The buccal marginal ridge of A.L. 199-1, A.L. 200-1a, A.L. 388-1, A.L. 333x-1, A.L. 161-40 and Garusi II is notched by the buccal groove which continues down the buccal surface as a shallow depression. A.L. 200-1a (right), like A.L. 199-1, A.L. 161-40, L.H. 8(b), Garusi II, L.H. 5 and A.L. 388-1, has a cervical line which projects between the two buccal roots, whereas that of A.L. 200-1a (left) is a straight line. The buccal surfaces of the A.L. 161-40, A.L. 200-1a, A.L. 333x-1 and A.L. 199-1 metacones have shallow grooves which run on the surface from the cervical line to the buccal marginal ridge.

Mesial View

The mesial cervical line of A.L. 200-1a, A.L. 388-1, A.L. 161-40, A.L. 199-1, L.H. 5,

Table 1. Metrical dimensions of maxillary permanent third molars of *Australopithecus afarensis*.

SPECIMEN	BL	MD	BL x MD	BL+MD/2	BL/MD x 100
A.L. 199-1	13.1[1]	11.4[1]	149.34	12.25	114.912
A.L. 200-1a	15.1[1]	14.3[1]	215.93	14.70	105.559
A.L. 333x-1	15.5[1]	13.6[1]	209.25	14.50	113.971
L.H. 5	13.4[2]	10.9[2]	146.06	12.15	122.936
A.L. 161-40	13.4[1]	11.8[1]	158.12	12.60	113.559
Garusi II	13.8[3]	10.9[3]	150.42	12.35	126.606

[1]Johanson *et al.* (1982)
[2]White (1980)
[3]Protsch (1981)

Garusi II and L.H. 8(b) is relatively straight. It projects between the buccal and lingual roots of A.L. 333x-1. The mesial surfaces of A.L. 200-1a, A.L. 333x-1, A.L. 388-1, A.L. 199-1, L.H. 5, A.L. 161-40, L.H. 8(b) and Garusi II flare mesiocclusally with a slight concavity cervically.

Distal View

The distal surface of L.H. 8(b) bulges outwards and is slightly bilobed, with a slight groove which is continuous with the median longitudinal groove. The distal surface of Garusi II is almost straight but the hypocone bulges more distally. The distal surfaces of A.L. 333x-1, L.H. 5, A.L. 161-40 and A.L. 200-1a are convex. Garusi II, L.H. 5, A.L. 161-40, A.L. 200-1a and A.L. 199-1 have straight cervical lines. Although the cervical lines are straight for A.L. 333x-1 and L.H. 8(b), they are obliquely placed with the lowest part being on the metacone.

METRIC ANALYSIS

The crown sizes and shape measurements (Table 1) indicate that A.L. 200-1a and A.L. 333x-1 have the largest buccolingual and mesiodistal dimensions. This is also true for the crown area and crown module which are measures of average crown dimensions and robusticity of the tooth, respectively. However, the crown shape index, an expression of the crown as a ratio of mesiodistal breadth to buccolingual length, is largest for L.H. 5, while A.L. 200-1a and A.L. 333x-1 have the lowest values.

DISCUSSION

This study adds significant information to our knowledge of *Australopithecus afarensis*. A bivariate analysis (Figure 1) indicates that A.L. 199-1, A.L. 161-40, Garusi II and L.H. 5 are closer to each other than they are to A.L. 200-1a and A.L. 333x-1. However, due to the small sample size, interpretation of this observation must proceed with caution. It appears that an appropriate interpretation of this analysis must rely mostly on morphological characters. This seems reasonable since, despite the small sample size, more morphological characters (Figure 2) are compared than has been done previously.

Out of the eighteen morphological features (Figure 2, A-R) analyzed, none of them separate the Hadar specimens from the Laetoli specimens. Apart from a wider V-shaped notch on the lingual marginal ridges of A.L. 200-1a and A.L. 333x-1, and the S-shaped anterior fovea of A.L. 200-1a, there are no specific morphological characters which differentiate the upper third molars of *A. afarensis* recovered from Laetoli from those recovered at Hadar. In most instances, the majority of features are shared in both the Hadar and the Laetoli specimens (Figure 2). For example, A.L.

Figure 1. Bivariate Plot of B/L Breadth x M/D Length in mm.

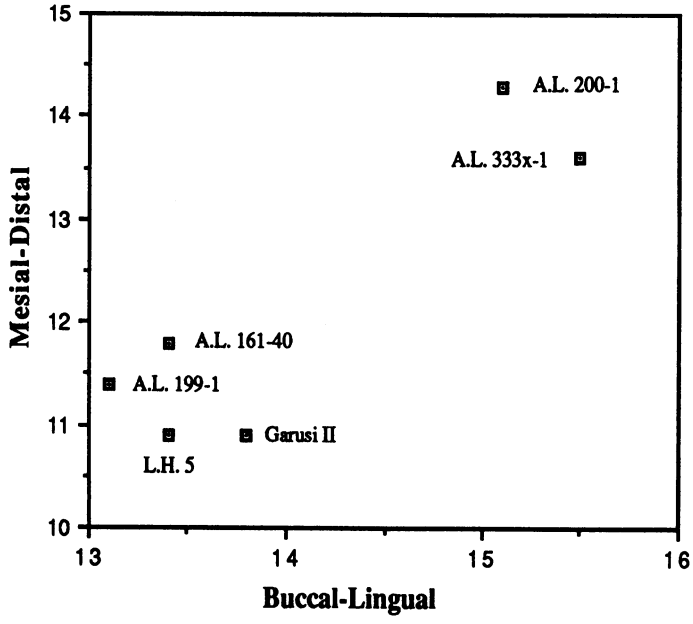


Figure 2. Comparisons of morphological characters.

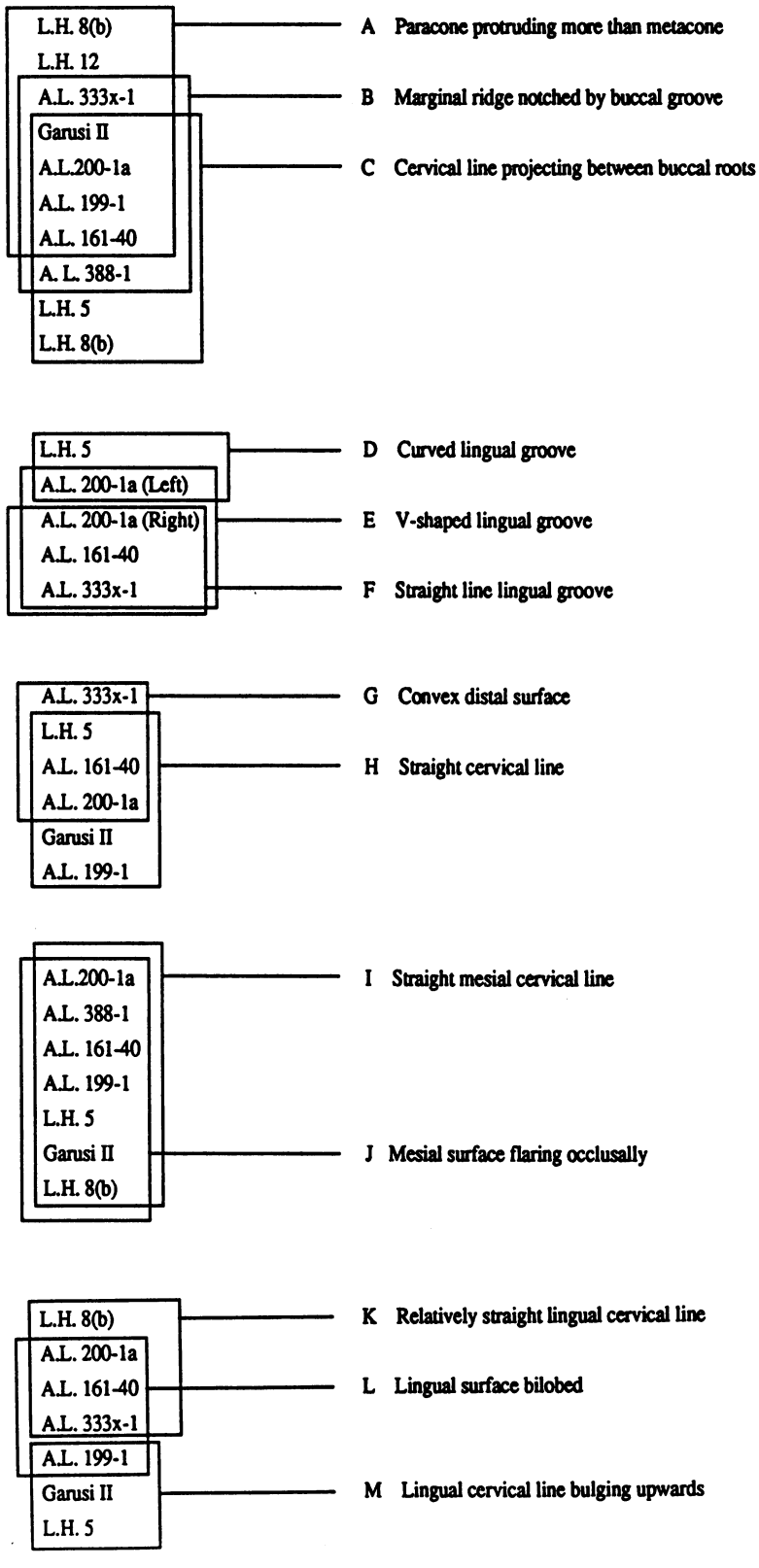
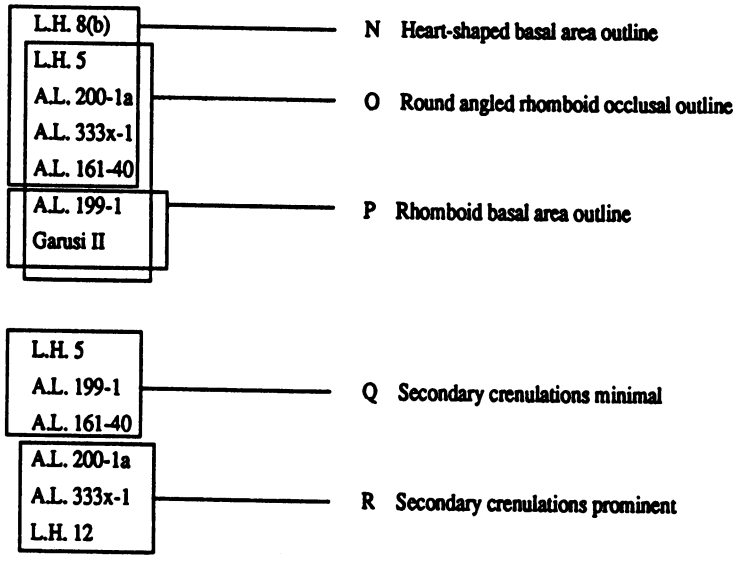


Figure 2, continued.



200-1a, A.L. 333x-1, A.L. 161-40, Garusi II, A.L. 199-1 and L.H. 5 share a rhomboidal occlusal surface outline. The outline of the occlusal view of A.L. 199-1 is rhomboidal, like that of Garusi II, while that of A.L. 200-1a, A.L. 333x-1, A.L. 161-40, L.H. 8(b) and L.H. 5 is heart-shaped.

Although minor morphological differences are apparent between the Hadar and Laetoli specimens, most likely they represent individual variation. This claim is strengthened by the fact that the maxillary third molars in *Homo sapiens* are known to vary more than any other maxillary tooth in both shape and size (Brand and Isselhard 1982). The chances that the differences are within the range of variation of a single species are hence very high. However, unless more specimens are found, the controversies will probably continue.

In sum, this study supports the combination of the Laetoli and Hadar samples attributed to *Australopithecus afarensis,* and shows that third upper molars of *A. afarensis* are highly variable. These observations reinforce the argument that the Laetoli and Hadar hominids, particularly in dental morphological characters, are conspecific (Grine 1985; Cole and Smith 1987; Johanson *et al.* 1978; Johanson and White 1979; White 1985).

ACKNOWLEDGMENTS

I wish to thank T.D White, F.C. Howell, G. Suwa and G. Richards for helpful comments on the manuscript; F.C. Howell and T.D. White for allowing me access to research materials and working space in their laboratory; and M. Black for graphic assistance. This work has been supported by the Wenner-Gren Foundation for Anthropological Research.

REFERENCES CITED

Biggerstaff, R.H. (1969) The area of posterior crown components: Within tooth variation of premolars and molars. *American Journal of Physical Anthropology* 31:163-170.

Blumenberg, B. and A.T. Lloyd (1983) *Australopithecus* and the origin of *Homo:* Aspects of biometry and systematics with accompanying catalog of tooth metric data. *BioSystems* 16: 127-167.

Brand, R.W. and D.E. Isselhard (1982) *Anatomy of orafacial structures.* London: The C.V. Mosby Company.

Cole, T.M. and F.H. Smith (1987) An odontometric assessment of variability in *Australopithecus afarensis. Human Evolution* 2: 221-234.

Coppens, Y. (1977) Evaluation morpholoque de la premere premolarie inferieure chez certain primates superieurs. *Comptes Rendus de l'Académie des Sciences.* Serie D 285:1299-1302.

Coppens, Y. (1980) The difference between *Australopithecus* and *Homo:* Preliminary conclusions from Omo research expedition studies. *In* L.K. Konigsson (ed.), *Current*

Argument on Early Man. Oxford: Pergamon. Pp.207-225.

Coppens, Y. (1981) Les cerveau des hommes fossiles. *Comptes Rendus de l'Académie des Sciences.* Académie Suppliment Serie I-II-III 292:3-24.

Coppens, Y. (1983) Les plus anciens fossiles d'hominides. *In* C. Chagas (ed.), *Working Group on Recent Advances in the Evolution of Primates, Pontificae Academiae Scientiarum Scripta Varia,* volume 50. Vatican: Pontificia Academia Scientrium. Pp.1-9.

Ferguson, W.W. (1983) An alternative interpretation of *Australopithecus afarensis* fossil material. *Primates* 24:397-409.

Ferguson, W.W. (1984) Revision of fossil hominid jaws from the Plio-Pleistocene of Hadar, in Ethiopia, including a new species of the genus *Homo* (Hominoidea: Hominidae). *Primates* 25:519-529.

Ferguson, W.W. (1989) Critique of *"Australopithecus afarensis"* as a single species based on dental metrics and morphology. *Primates* 30:561-569.

Grine, F.E. (1984) *The Deciduous Dentition of the Kalahari San, the South African Negro and the South African Plio-Pleistocene Hominids.* University of Witwatersrand, Johannesburg, Ph.D. dissertation.

Grine, F.E. (1985) Australopithecine evolution: The deciduous dental evidence. *In* E. Delson (ed.), *Ancestors: The Hard Evidence.* New York: Alan R. Liss, Inc. Pp.153-167.

Herbert, W. (1983) Lucy's family problems. *Science News* 124:8-11.

Johanson, D.C., T.D. White and Y. Coppens (1978) A new species of the genus *Australopithecus* (Primates: Hominidae) from the Pliocene of Eastern Africa. *Kirtlandia* 28:1-14.

Johanson, D.C., T.D. White and Y. Coppens (1982) Dental remains from the Hadar Formation, Ethiopia: 1974-1977 collections. *American Journal of Physical Anthropology* 57:545-604.

Johanson, D.C. and T.D. White (1979) A systematic assessment of the early African hominids. *Science* 203:321-330.

Leakey, R.E. (1981a) *The Making of Mankind.* New York: Dutton.

Leakey, R.E. (1981b) Tracks and Tools. *Philosophical Transactions of the Royal Society of London,* series B 292:95-102.

Leonard, W.R. and M. Hegman (1987) Evolution of P3 morphology in *Australopithecus afarensis. American Journal of Physical Anthropology* 73:41-63.

Olson, T.R. (1985) Cranial morphology and systematics of the Hadar Formation hominids and *"Australopithecus" africanus. In* E. Delson (ed.), *Ancestors: The Hard Evidence.* New York: Alan R. Liss, Inc. Pp.102-119.

Senut, B. and C. Tardieu (1985) Functional aspects of Plio-Pleistocene hominid limb bones: Implication for taxonomy and phylogeny. *In* E. Delson (ed.), *Ancestors: The Hard Evidence.* New York: Alan R. Liss, Inc. Pp.193-201.

Tardieu, C. (1986) The knee joint in three hominoid primates: Application to Plio-Pleistocene hominids and evolutionary implications. *In* D.M. Taub and F.A. King (eds.), *Current Perspectives in Primate Biology.* New York: Van Nostrand Reinhold. Pp.182-192.

Tobias, P.V. (1980) *Australopithecus afarensis* and *Australopithecus africanus:* Critique and an alternative hypothesis. *Palaeontologica Africana* 23:1-17.

Tuttle, R.H. (1981a) Paleoanthropology without inhibitions. *Science* 212:798.

Tuttle, R.H. (1981b) Evolution of hominid bipedalism and prehensive capabilities. *Philosophical Transactions of the Royal Society of London,* series B 292:89-94.

Tuttle, R.H. (1985) Ape footprints and Laetoli impressions: A response to the SUNY Claims. *In* P.V. Tobias (ed.), *Hominid Evolution: Past, Present and Future.* New York: Alan R. Liss, Inc. Pp.129-133.

Tuttle, R.H. (1987) Kinesiological inferences and evolutionary implications from Laetoli bipedal trails G-1, G-2/3 and A. *In* M.D. Leakey and J.M. Harris (eds.), *Laetoli: A Plio-Pleistocene Site in Northern Tanzania.* Oxford: Clarendon. Pp.503-523.

White, T. D. (1977) New fossil hominids from Laetoli, Tanzania. *American Journal of Physical Anthropology* 46:197-229.

White, T. D. (1980) Additional fossil hominids from Laetoli, Tanzania: 1976-1979 specimens. *American Journal of Physical Anthropology* 53:487-504.

White, T. D. (1985) The hominids of Laetoli and Hadar: An element by element comparison of the dental samples. *In* E. Delson (ed.), *Ancestors: The Hard Evidence.* New York: Alan R. Liss, Inc. Pp.138-152.

White, T.D. and G. Suwa (1987) Hominid footprints at Laetoli: Facts and interpretations. *American Journal of Physical Anthropology* 72:485-514.

Zihlman, A.L. (1985) *Australopithecus afarensis:* Two sexes or two species? *In* P.V. Tobias (ed.), *Hominid Evolution: Past, Present and Future.* New York: Alan R. Liss, Inc. Pp.213-220.